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Sensitivity Testing of Property/Casualty Cash Flows

Ralph S. Blanchard, III* and Eduardo P. Marchena†

Abstract†

The paper outlines an approach that has evolved at Aetna through ten years of property/casualty insurance cash flow testing. Methodologies and approaches to setting parameters reflecting both default and call/prepayment risk are discussed for major invested asset categories. Modeling runoff cash flows for a base scenario (and, for some of these assets, shocked scenarios) also is examined for major non-invested asset categories. Loss reserve cash flow modeling is not addressed, except for a brief description of one approach to shocking projected flows. Finally, various alternatives are given for presenting cash flow testing results to management and non-actuarial audiences.

Key words and phrases: interest rate scenarios, assets, liabilities, default risk, prepayment risk

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1 Introduction

The late 1970s and early 1980s was a time of volatile financial conditions. Interest rates had risen to unprecedented levels. In this environment, statutory annual statements were inadequate to assess a company's financial condition. This provided the impetus to perform an analysis focusing on financial strength in its most basic form: the ability of a company to meet its cash obligations during periods of adverse financial and experience conditions. The first property/casualty "mismatch", i.e., interest rate risk, analysis was completed by Aetna's corporate actuarial department in July 1982. It took the form of a cash flow runoff of the company's December 31, 1981 balance sheet.

Since 1982 the analysis has been performed annually. While the first study's focus was interest rate risk, the focus has shifted as we have come to better understand the major risk factors affecting the property/casualty balance sheet. Today, the analysis focuses on default risk for bonds and commercial mortgages, refinancing risk for commercial mortgages, certain off-balance sheet risks, and reserve development risk. Interest rate risk is still evaluated, primarily via asset prepayment scenarios and present value measures, but interest rate effects are secondary to the other risk factors in their importance to the overall property/casualty cash flows. This is because of the relatively short duration of property/casualty liabilities, the lack of any call risk for these liabilities (unlike many life insurance products), and the fact that the level of liability is not directly a function of interest rates (again unlike many life insurance products). Our analysis techniques have tended to evolve as the various sources of risk have become better understood to us (e.g., CMO risk in 1992).\footnote{1}{It is rare to see a total property/casualty ("p/c") company liability duration over 4.}

\footnote{2}{P/C liabilities are also either fixed or a function of inflation, not a function of interest rates. P/C liabilities correlation with interest rates exists only to the extent that interest rates correlate with current inflation. These p/c vs. life liability differences also produce significant contrasts in the focus of our analysis vs. traditional life analysis. We do not construct life "like" interest rate scenarios and we do not explicitly model asset reinvestments or disinvestments (the short durations make reinvestment risk a non-issue). Interest rate scenario issues related to coordinating projected liability cash flows with asset cash flows are largely "non-issues" for p/c.}

\footnote{3}{A collateralized mortgage obligation (CMO) is a mortgage-backed security supported by a nonproportional sharing of the principal (and/or associated interest) payments from a pool of mortgages. For example, an individual CMO could be supported by the first (or last) $X$ dollars of principal payments/prepayments. The mortgage principal repayments (and/or their associated interest payments) are separated, based on repayment date, into short-, medium-, and long-term segments.}
Over the years the results have been presented to senior management and to rating agencies. The analysis also has been used by Aetna's property/casualty portfolio managers as a tool in understanding the cash needs of the business (on a runoff basis) and in managing the degree of mismatch between the asset cash flows of their portfolios and the cash flows of the liabilities.  

This paper focuses on how we have modeled expected asset cash flows (following statutory annual statement page 2 line categories) and the approach we have taken to shock certain asset categories to reflect defaults, prepayments, and refinancing (for mortgages). This baseline and shock modeling have been done on a deterministic, rather than on a stochastic basis because our focus has been what it would take to break the bank, not on the probability of survival.

For non-invested assets, the discussion will be brief except for the accrued retro premium account (line 9.3). We will discuss how we tie this item to loss assumptions.

Certain items on the liability side also will be discussed, but in a summary fashion. The most significant of these liability items are the emergence of possible adverse loss development and the runoff of existing unexpired policies.

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4While the model only projects runoff flows, some components of it also have been used to model various ongoing business flows on an ad hoc basis. As the requirements for dynamic solvency analysis develop, we expect to use more of the model's output and modules for ongoing business cash flow analysis, with the possible expansion of the entire model in the future for ongoing business scenarios.

5The term shock is used throughout this paper to refer to the process of subjecting a financial asset or liability to an extreme scenario.

6We leave a full discussion of stochastic versus deterministic modeling for future papers. We can say, however, that many of the past property/casualty shocks were not adequately predicted by stochastic models. For example, the January 1994 Northridge earthquake was deemed physically impossible by many earthquake risk models before the event.

7This account reflects future premium collections expected on cost plus (i.e., retro) policies whereby the final premium is based on actual rather than expected losses. Due to the tendency of property casualty losses to develop (i.e., increase) over time for a single policy, premium tends to develop (i.e., increase) over time for a single retro policy. The result is a stream of retro premium collections almost as long as the loss payment pattern for a policy, causing significant dollars for this asset account.

8As this paper focuses on asset risk rather than liability risk, only a summary of liability risks is given here.
2 Invested Assets

In describing our cash flow analysis and how it begins each year, the key words are communication, communication, and communication. Reserve issues are identified through discussions with our property/casualty reserve actuaries, cash flow methodology issues are discussed and peer review is solicited from our life actuaries, and invested asset issues are identified and discussed with our portfolio managers. These discussions also lead to adjustments in the detail\(^9\) in which the cash flows are modeled depending on whether there are any significant unique (in terms of cash flow) items buried in the asset or liability categories of the balance sheet.

For the invested assets we look to the portfolio managers for expertise. We rely on them to provide the asset cash flows under various scenarios (based on individual asset characteristics).

2.1 Bonds (Excluding Mortgage-Backed Securities)\(^10\)

2.1.1 Prepayment/Calls Risk

Following these discussions bond cash flows are provided by the portfolio managers under three prepayment scenarios reflecting a range of possible interest rate conditions. The scenarios include a baseline scenario that reflects projected cash flows under current interest rate expectations, a shortest probable scenario that reflects the largest volume of prepayments expected if interest rates drop, and a longest probable scenario reflecting the least volume of prepayments expected if interest rates rise.

- **Base Case Cash Flow**—Callable bonds are assumed to call (or prepay) if the coupon exceeds 150 basis points of projected treasury returns.\(^11\)

- **Shortest Probable Cash Flow**—All callable bonds call at the earliest opportunity.

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\(^9\) *Detail* here refers to the number of different asset or liability classes. Our model generally deals with aggregate flows for an asset or liability class. Modeling of individual asset detail within each class is done, but by our investment area in deriving the data feeds submitted to us.

\(^10\) At the time we were developing our model, the only significant asset-backed securities Aetna held were mortgage-backed securities. Therefore, our model, and hence our paper, does not address other types of asset-backed securities.

\(^11\) For the 1993 analysis interest rates were assumed to rise through 1998 and then remain level. (The 150 basis point criterion is specific to the composition of our portfolio.)
• **Longest Probable Cash Flow**—Bond cash flows follow prescribed sinking fund schedules/maturity dates. (Pre-refunded bonds are assumed to prepay.)

The primary focus of the multiple scenarios is not any one scenario; it is the range of results when different cash flows are combined with other balance sheet cash flows in our model.

The key to reflecting prepayments in our bond cash flows rests with the modeling capability of our portfolio managers. The database they currently maintain contains specific contractual terms of each bond held—whether there is a call provision, the maturity date and coupon rate, and several other data fields. The database with its associated software is capable of modifying cash flows in response to specified criteria.

2.1.2 Default Risk\(^\text{12}\)

The bond cash flows exclude bonds already in default, but make no allowances for future defaults. Some additional allowance must be made. Our current methodology does this by first determining a default rate and then shocking the bond cash flows for various multiples of that rate. An additional adjustment is made for recoveries from bonds in default.

**Selecting a Default Rate:** We currently use three different methods to produce a default rate and then make a judgmental selection.

The most scientific of our methods is based on the work of Altman (1989). Altman's principal message is that default risk is partly a function of time. Bonds rated AAA default less frequently than bonds rated BBB. But the longer into the future one goes, the more likely it is that today's AAA bonds will default. This makes intuitive sense, as no rating agency would rate a bond AAA if it faced significant default risk today. Over time, however, even strong companies can weaken and default.

Altman includes a table of cumulative default rates by current bond rating and lag year.\(^\text{13}\) This table is updated annually in a

\(^{12}\)This default risk models the risk of defaults across the entire portfolio, not the risk from asset concentration (i.e., a significant portion of assets from a single issuer and subsequent default of that issuer). To date we have not found asset concentration to be a problem, partly due to the size of Aetna, and partly due to state laws limiting asset concentration for property/casualty investment portfolios.

\(^{13}\)For example, for bonds currently rated A, he shows the probability of default in one year, in two years, etc.
report published by Moody's Investors Service (1994). We ideally would apply this table of default rates, by bond rating and lag year, to our bond cash flows, by bond rating and lag year. Instead we have resorted to a simpler calculation, whereby we use a readily available statutory annual statement schedule (containing summarized principal flows for broad asset classes)\(^{14}\) to produce weighted average portfolio default rates by lag year. (See Appendix for more details.) This seems to produce reasonable numbers for about 14 lag years. The data underlying the default tables are too sparse beyond this period.

Next we analyze our own historical bond default rates. This is a check on whether the previous method's result is reasonable. It also quantifies the value added by our own investment department (in their independent analysis of borrower credit risk).

After completing analyses with these two methods we are ready for a discussion with our investment department. We discuss our findings with respect to default rate assumptions, ask them what they think a reasonable default rate is (as our third method), and select a final estimate.

We currently apply the same default rate assumption to every year of our bond flows. This is somewhat counter to Altman, whereby default rates should rise gradually over time. Our response is to pick a rate that is conservative for the first several years and in line with what we believe the default rate will be for the middle to later years.

**Applying the Selected Default Rate:** After choosing the annual default rate assumption we apply it to the outstanding bond principal at each year end. We track the cumulative amount of total outstanding principal defaulted for each year and assume the interest flow is reduced in the same proportion. For example, if we assume a 2 percent default rate in years 1 and 2, then we assume that 4 percent of year 2 interest disappears.

**Default Recoveries:** It is rare when a bond defaults for creditors to lose all their investment. The Moody's report includes an analysis of ultimate recovery rates, i.e., how many cents are recovered per dollar of principal owed. Default recovery rates calculated this way are generally between 40 percent and 60 percent. We combine general data from such sources with input from our investment

\(^{14}\)Schedule D - Part 1A of the property/casualty statutory annual statement.
department to select a recovery rate. The selected recovery rate then is applied to defaulted principal, and a lag of two years between year of default and year of recovery is used to model the default recoveries.

2.2 Bonds: Mortgage-Backed Securities

2.2.1 Prepayment/Calls Risk

Mortgage-backed securities are instruments whose cash flows depend on the cash flows from an underlying pool of mortgages. As the mechanism driving prepayments is different from other bonds, our portfolio managers model these assets separately. Our discussions with our portfolio managers have focused on two types of these securities: (i) mortgage pass-through securities, which are a straight percentage share of a pool of mortgage flows, and (ii) CMOs whereby the owner’s share of the underlying pooled mortgage flows is not proportional.15 Fabozzi and Ferri (1991, Chapter 2, page 27) state:

The cash flow for each class of CMO can be derived only by assuming some prepayment rate for the underlying mortgage collateral. The prepayment benchmark used by mortgage-backed securities dealers to quote CMO yields is the PSA16 standard prepayment model.

In addition, Parseghian (1991, Chapter 29, page 632) states:

The universe of CMO tranches17 has vastly differing sensitivity to prepayment rates on underlying collateral. To the extent that this sensitivity causes risk, the investor must be compensated in the form of yield.

For our model we see only an aggregation of cash flows for these securities. The complex modeling issues related to CMO prepayments at Aetna are in the realm of portfolio managers. Our focus can be summarized by three questions:

1. Are the base case cash flows realistic in the current environment?

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15 One example of a nonproportional sharing of these flows is to participate instead in the first X dollars of principal repaid. The varieties of nonproportional sharing of the underlying mortgage flows (principal and interest) are endless.

16 Authors' note: PSA = Public Securities Association.

17 The segments of principal (and/or associated interest) repayments in a CMO are called tranches.
2. How short could the flows get? And
3. How long could the flows get?

From Hu (1990):

A mortgage pool whose prepayment experience conforms to the PSA pattern is said to prepay at 100 percent of the PSA model. Any slower or faster prepayment speed is a fraction or multiple of that PSA model.

From about 1989 to 1992 our portfolio managers used the PSA method to produce cash flows for different interest rate scenarios. In those years we used 100 percent of PSA for our base case cash flow, ten times PSA for a scenario reflecting a significant drop in interest rates (i.e., high prepayments, comparable to the shortest probable bond scenario), and 50 percent of PSA for a scenario reflecting a rise in interest rates (i.e., low prepayments, comparable to the longest probable bond scenario).

In 1992 interest rates fell significantly, however, and as our discussions with portfolio managers progressed in early 1993 we became aware that the PSA-based model was not doing a good job of modeling prepayments on our CMOs. With preliminary analysis results already in hand, our portfolio managers provided new cash flows for CMOs. Reflecting the heavy volume of prepayments, the new flows showed substantially more cash in the early runoff years and substantially less in total. This strengthened our financial position with respect to interest rate risk at least, because the new asset cash flows were well-matched to our liability cash flows.

Our portfolio managers continue to provide us with asset cash flows and prepayment scenarios reflecting separate treatment for mortgage-backed securities. The modeling techniques for these assets have been changing, however, since the need became apparent during the 1992 cash flow analysis. For our 1993 analysis our three mortgage-backed security cash flow scenarios were developed according to the following interest rate assumptions:

They also had the capability to develop expected prepayment rates based on the specific characteristics of each security held. The expected rate reflected two classes of factors: (i) demographic turnover (factors related to the personal characteristics of the mortgagor, e.g., persons tend to move after a certain number of years); and (ii) refinancing activity (factors reflecting the economic motivation of the mortgagor).

This is not unexpected for property/casualty insurance, as most property casualty companies manage their assets to a higher duration than their liabilities. This purposeful mismatch results from a lack of call risk on the P/C liabilities. Given the lack of call risk, companies typically manage first to meet liquidity needs and then to maximize yield (by going long on the assets). The model being discussed is one way for P/C companies to evaluate the risk this strategy takes.
• **Base Case Cash Flow**—Interest rates remain at current levels.

• **Shortest Probable Cash Flow**—Interest rate decrease 300 basis points from current levels.

• **Longest Probable Cash Flow**—Interest rates increase 300 basis points from current levels.

In determining these scenarios we asked portfolio managers for the longest and shortest cash flows possible in the context of changing interest rates (as well as their current base expectation). In their judgment the 300 basis point range produced the cash flow effects (on our portfolio) consistent with our request.

Our experience with mortgage-backed security prepayments highlights a crucial point that applies to all our cash flows and to modeling generally: methods or experience that produced reasonable estimates in the past may not produce reasonable estimates in the future. Again, the key to ensuring the validity of the modeled asset cash flows is communication with those who are managing the assets and modeling the expected asset cash flows. They will know if economic conditions are producing asset behavior that is unexpected or differs significantly from past models.

### 2.2.2 Default Risk

For purposes of default we have not developed a separate approach (or rate) for mortgage-backed securities. The cash flows for these assets are aggregated with those of our other bonds, and the default methodology is applied in our model.

This is consistent with how the bond default selections are made. The analysis using bonds by NAIC rating class includes all bonds, including mortgage-backed ones. Therefore, we believe that, in total, our bond default assumptions are reasonable. The default assumptions should vary, however, if separate assumptions are made for mortgage-backed bonds versus noncollateralized bonds. Many mortgage-backed securities include government agency guarantees (e.g., Ginnie Maes) with minimal, if any, default risk.

This aggregation of all bond types for default risk purposes raises an important issue, namely the importance of defining in advance the scope of investment department discussions. Investment departments may not be organized in accordance with annual statement page 2 asset
categories.\textsuperscript{20} Separate departments may exist for private versus publicly traded, mortgage-backed versus noncollateralized, and/or government versus corporate bonds. When discussing asset risk parameters, care should be taken that all relevant portfolio managers are represented. Otherwise, one may find that the value selected to measure asset risk is reasonable only for a small segment of the assets in question.

2.3 Commercial Mortgages\textsuperscript{21}

2.3.1 Prepayment/Calls Risk

When we raised the issue of modeling commercial mortgage prepayment behavior with our portfolio managers, the discussion was short. Our portfolio managers looked quizzically at each other and answered "Mortgages don't prepay."

Of course, our portfolio managers were not talking about residential mortgages. They were speaking about our portfolio of commercial mortgages. Because commercial property owners with mortgages will pass the cost of their mortgage debt to renters, the prepayment behavior of these assets is different—they tend not to prepay. Also, in the economic climate of the early 1990s for commercial real estate, it was difficult for commercial mortgage loan holders to refinance even if they wanted to. This was a time of falling property values and tight credit—prepayments were not a major issue. Under different circumstances a more careful analysis of the expected prepayments may be necessary.

The significant issues in modeling commercial mortgage loan cash flows are default (and refinancing) and the underlying property values.

2.3.2 Default/Refinancing Risk

Our default analysis starts with the mortgages' contractual flows, with principal and interest flows separated, and balloon principal separated from other scheduled principal. Unfortunately, in the economic environment of the early 1990s contractual flows are probably not going to be realized, particularly for balloon mortgages. Therefore, our

\textsuperscript{20}The balance sheet is shown on the statutory annual statement pages 2 and 3 (assets and liabilities/surplus, respectively).

\textsuperscript{21}We only address commercial mortgages because residential mortgage investments are rare. Mortgages in general are rare investments for most p/c companies. Aetna has been an exception. In 1994 Aetna represented only about 2.3 percent of the p/c industry's invested assets, but held nearly 48 percent of the industry's mortgages.
portfolio managers adjust the contractual mortgage flows to the extent that actual flows are expected to differ from the original contract terms. These adjustments are for specifically identified problem or near problem loans. Adjustments include refinancing loans (in which case our receipt of principal is delayed but we receive more interest payments), retiring the loan but at a reduced amount, and foreclosure.

The refinancing risk is primarily in balloon mortgages. For these mortgages scheduled payments are generally interest only, with the entire principal balance (the balloon) due upon maturity. For commercial mortgages the balloon can be large. The borrower typically never expects to pay the debt, but instead to continually roll it over, i.e., pay the balloon with proceeds from a new loan. This may have worked during the real estate craze of the 1980s, but when real estate values dropped and credit tightened these borrowers found that they could not obtain refinancing. As lenders we are left with a choice: either foreclose or extend the loans.

The flows adjusted by portfolio managers reflect defaults, but only to the extent that defaults are known or considered likely on specific mortgages. In the language of asset impairment reserves, specific impairments are reflected, general impairments are not. Therefore, to arrive at our base case mortgage cash flows including future default risk, we apply a selected default rate to the cash flows. The algorithm used to model the defaults is the same as for bonds. The assumptions on default rate, recovery rate, and lag between default and recovery, however, must be reviewed and changed if appropriate.

For the recovery rate and lag we generally have taken a fairly broad approach. These assumptions have been selected based upon discussions with our portfolio managers. (We generally look for assumptions that they judge to be reasonable but on the conservative side.) For the default rate we test the effects of various default rates and then discuss the various impacts with our mortgage portfolio managers. One perspective that we have found helpful is the reduction to the all time yield (in basis points) of the portfolio as implied by the cash flows. This can be measured by calculating the internal rate of return of the flows before and after application of the default rate. (All you need are the beginning outstanding principal and the cash flows.)

With the base case mortgage cash flows set through this process, more adverse scenarios of mortgage experience are modeled by shocking the flows at multiples of the base default rate.
2.4 Other Invested Assets (Including Stocks)

Other invested assets include cash and short-term investments, stock, and real estate. At Aetna these assets are small in relation to bonds and mortgages, and our approach to modeling them is correspondingly simple. We generally have assumed that these assets are converted to cash in the first year of the runoff.\textsuperscript{22}

One exception is real estate. It may not be reasonable to assume that real estate can be sold within a year. Therefore, in our most recent analysis we differentiate between investment grade and foreclosed real estate and assume that the latter produces a three year cash flow at less than the current GAAP value.

In evaluating these asset categories it is important to keep in mind that we are performing a runoff analysis, not a fire sale. This should be considered before one starts to convert occupied real estate and stock of affiliates to cash. We do not reflect any cash flows from these assets in our analysis.

3 Non-Invested Assets

The largest annual statement non-invested asset categories are typically agents balances (page 2, line 9 of the annual statement), reinsurance recoverable on loss payments (page 2, line 12), and interest, dividends, and real estate income due and accrued (page 2, line 15). With the exception of the accrued retrospective premiums (the portion of agents balances relating to cost plus or retro policies, see footnote 7), we assume that the cash is received in the first year of the runoff. We have not performed any analysis of collection risk associated with these items, relying instead on statutory non-admitted asset rules and Schedule F penalties\textsuperscript{23} to reflect collection risk. We do not reflect any cash flow for items such as property and equipment.

3.1 Accrued Retrospective Premiums (A.S. Page 2, Line 9.3)

Aetna has been a large commercial lines writer of retrospectively rated (i.e., retro) policies in the auto, general liability, and workers' compensation lines of business. Hence, this asset has been significant for

\textsuperscript{22}Transaction costs of the sale could be reflected through a reduction to the assumed cash flow.

\textsuperscript{23}Schedule F is the property/casualty annual statement schedule showing information on reinsurance transactions. Parts 4 through 7 are used to develop a penalty, essentially a formula-based credit risk reserve for reinsurance collection risk.
us. In our analysis we group this asset with our liabilities (showing it as a negative outflow) because the expected additional premiums are directly connected to the losses on this business. There are two aspects of the expected cash flows that we will discuss here: the runoff of the held retro premium reserve and adverse loss development scenarios.

**The runoff (lines 9.3 and related impacts on lines 9.2 and 9.1)**—Agents balances (page 2, line 9) are split in the annual statement into three pieces:

- **line 9.1** Premiums and agents' balances in course of collection;
- **line 9.2** Premiums and agents' balances and installments booked but not yet due;
- **line 9.3** Accrued retrospective premiums.

When projecting how the accrued retrospective premium asset runs off, one must recognize that modeling the runoff of this asset is not the same as modeling cash receipts.

The retro premium reserve represents future premiums to be written as reported incurred losses (paid plus case basis reserves) develop on retrospectively rated policies. As the losses emerge, the additional premium is booked and then billed (i.e., there is a shift—line 9.3 goes down and 9.1 goes up). As the bill is paid, line 9.1 goes down and cash goes up. On our book of business, however, it is not this straightforward. For some retro policies the amount of premium booked is based on reported incurred losses, but the amount billed is based on reported paid losses. In this case line 9.3 goes down by the amount booked, line 9.1 goes up by the amount billed, and line 9.2 goes up by the difference between the booked and billed premium. (For statutory accounting, the amount in line 9.2 must be secured by a bank letter of credit or other collateral; otherwise it is non-admitted.)

To reflect how the retro premium asset converts to cash (and also how line 9.2 becomes cash), it is necessary to understand the various billing arrangements available to the insured. In our case the cash is received more slowly than a pure runoff of the line 9.3 asset would indicate.

**Retro premiums and adverse loss development**—While not a focus of this paper, adverse loss development scenarios are a major focus of our cash flow analysis. To model these adverse scenarios appropriately, it is necessary to recognize that with higher losses more retro premiums will be collected than what is anticipated by the held retro premium reserve. In our analysis we reflect additional retro premiums (above the held reserve level) in the following way:
• First, we separately identify how much of auto, general liability, and workers' compensation loss reserves are associated with retro policies.

• We assume that the loss payment pattern is the same for both guaranteed cost and retrospectively rated business and that adverse loss payments in each runoff year are split in the same proportion as the original reserves.

• For each runoff year we associate the marginal amount of increased loss payments with a marginal increase in reported case reserves. We produce the case reserve increase by assuming that the case reserves will anticipate the future adverse loss payments for a specified horizon (i.e., a specified number of future years).24

• For each runoff year the product of the marginal increase in reported case reserves and a retrospective premium responsiveness factor (developed through a separate review of the retrospective premium reserve) produces the additional retro premium received. The responsiveness factor is a ratio representing the expected additional premiums per dollar of additional reported loss. The factor incorporates, in aggregate, the individual characteristics of all our retrospectively rated accounts, e.g., specified aggregate loss limitations (maximums on the retro contract).

Via an interpolation formula in our cash flow spreadsheet we cause the responsiveness factor to vary inversely with the severity of the loss development scenario. This reflects the fact that at higher levels of loss development more insureds will reach their maximums and the additional retro premiums received will diminish in relation to the amount of additional losses.

We show the additional retro premiums received as offsets to the loss payments (i.e., negative outflows).

4 Loss Development

Our base case projected loss and loss adjustment expense payments are produced by multiplying the held reserve levels by a reserve payout

\[\text{24The shocked reserves of year } X = \text{the base case reserves of year } X + \text{the impact of the shock on payments for next } Y \text{ years. The choice of } Y \text{ allows for a gradual recognition of the shock in the reserves.}\]
pattern. These payout patterns are developed in a separate analysis and are in the annual statement Schedule P line detail.

We describe one algorithm that can be used to produce loss payments given a targeted adverse loss development scenario. There is no one right way to do this, however. This method should be viewed as appropriate for a plain vanilla analysis where the primary objective is to mechanically vary loss payments, in both amount and timing, over a range of scenarios. The easiest way to describe the algorithm is with a few formulas.

Let $H$ represent the current held loss and loss adjustment expense reserve and $P_i$ represent the base loss and loss adjustment expense payout in runoff year $i$, for $i = 1, 2, \ldots, n$ where $n$ is the number of years needed to retire all current liabilities. Then

$$H = \sum_{i=1}^{n} P_i.$$  \hspace{1cm} (1)

Next we let $T$ be the targeted development scenario. (For example, if the scenario represents projected loss payments exceeding the held reserves by 10 percent, then $T = 1.1H$.) For each runoff year assume that the payments under the adverse scenario are related to the base scenario by a constant factor $c$ raised to a power, where the power is the index of the runoff year, i.e.,

$$T = \sum_{i=1}^{n} P_i c^i.$$  \hspace{1cm} (2)

Equation (2) is just a polynomial of degree $n$ in $c$ and can be solved for the unknown $c$ using standard numerical techniques such as the Newton-Raphson method; see, for example, Burden and Faires (1985, Chapter 2). Use of the exponential relationship lengthens the payout pattern relative to the base pattern, but this may be a reasonable way to model the adverse payments. (One could take the view there is relatively more uncertainty associated with the projected payments far into the future than with the projected payments in nearer years.) Most of the dollars of development will occur early in the runoff because the volume of loss payments is much greater in these years than in the outer years.

25There are some components of the held reserve that are excluded because no reasonable base payout pattern can be developed, e.g., for asbestos reserves.

26Schedule P is the analytical loss schedule—showing loss information by accident year—of the property/casualty annual statement.

27This will tend to be true for all but the most extreme levels of targeted development.
At high levels of development and with long tailed lines of business this method may put more development in the tail than is desired. To add more flexibility in controlling the timing of the additional loss payments we have modified the approach by dividing the polynomial into two sections. (Newton's method applies.) For earlier payments the same expression is used, with the increasing exponent, up to a specified year. After the specified year, say runoff year \( m \), the exponent is kept constant (i.e., \( P_i c^i \) is replaced with \( P_i c^m \) for \( i \geq m + 1 \)). This allows us to maintain the original pattern or to vary the lengthening of the pattern anywhere between this (no change) and the full exponential approach.

5 Other Liabilities

5.1 Unearned Premium Reserve (UPR)

The unearned premium reserve reflects a commitment to provide loss coverage for a limited period following the balance sheet date. In our analysis we reflect this future commitment by developing an expected combined ratio for the unexpired portion of currently in-force business. The product of this combined ratio and the UPR, less prepaid expenses, produces the total future outflows associated with the UPR. To obtain cash flows we apply a loss and loss adjustment expense payout pattern to the total loss amount and assume that other expenses (excluding prepaid expense) are paid in the first runoff year. The loss and loss adjustment expense payout pattern for the UPR should reflect that the loss exposure is not even over the UPR coverage period, i.e., the highest exposure is in the first quarter and exposure then decreases in each future quarter. This shortens the payout pattern relative to an accident year pattern.

The method described requires the UPR to be an appropriate measure of the future loss exposure as of the balance sheet date. This may not be true, however, depending on how premiums are booked. For some of our commercial lines business premium is accounted on a booked-as-billed basis. The amount of written premium that is booked depends on the billing arrangement of the policy and does not necessarily represent the full term premium of the policy. Likewise, the unearned premium reserve for the policy does not reflect the total future loss exposure on the policy.\(^{28}\) Therefore, when we project the future

\(^{28}\)For example, suppose a $120 annual policy is billed in four quarterly installments, and the premium is booked as billed. Then the booked written premium at the begin-
outflows on the UPR we first adjust the UPR upward for these not yet booked or earned premiums. These premiums also represent future cash inflow.

Finally, our model includes the capability to shock the future loss payments on the UPR according to the adverse (shocked) loss development scenario selected. This is done by runoff year by taking the ratio of shocked to unshocked loss payments on the loss reserves and then applying this ratio to loss payments on the UPR. (We do this for all lines combined, not line by line.)

5.2 Accrued Expense and Other Liabilities

These liabilities include various accounts payable (including outstanding general expenses), funds held on account of others, and various accruals. For the insurance liabilities all we do is assume that the balance sheet amount is paid in the first runoff year.

Insurance liabilities are highlighted because we perform our analysis on two separate balance sheets. One balance sheet includes only the insurance liabilities and only those assets supporting those liabilities. (We maintain separate investment portfolios, one to support insurance liabilities and one to support statutory surplus.) The other balance sheet includes assets supporting surplus plus several corporate liabilities such as accruals for postretirement benefits other than pensions (OPEBs, FAS 106) and corporate debt. We limit our discussion of OPEBs to an observation that they are of long duration.

5.3 Taxes

A detailed discussion of taxes is beyond the scope of this paper. Furthermore, in our analysis we have taken a broad brush approach to the tax question, and we feel this is reasonable in the context of the intended use of the analysis.

In most of our past analyses we have ignored the effect of taxes. The purpose of our analysis is to see if we can withstand extreme shock scenarios, not to forecast future expectations. We always have assumed that these shocks would be so severe that federal income tax payments would be zero.

We recently have included a rough tax calculation in our model involving a calendar year taxable income base for each year of the runoff period of each quarter is $30, and the associated unearned premium is $30. The balance sheet unearned premium reserve will not reflect the full loss exposure committed to under the policy.
and a calculation of the incurred tax payable. This requires tracking any net operating loss carryforwards available to the company; splitting investment income to taxable versus nontaxable components; tracking future investment income and losses from defaults; and tracking reserve runoffs, reserve strengthening, and the associated tax loss reserve discount factors. We have not reflected any alternative minimum tax in the tax flows.

One significant question in modeling the timing of tax flows is how to model the loss and loss adjustment expense reserve balances. Our loss development method produces higher loss payments in the runoff years which in total equal a selected target development. The question is to what extent do the loss reserves anticipate the future adverse loss payments at each runoff year end (i.e., how is the reserve funded to meet the adverse loss payments)? Our approach has been to specify a certain horizon of future years adverse loss payments that the reserve responds to (for example, shocked year \(i\) reserve = unshocked year \(i\) reserve + shock payments for the next \(j\) years). The number of years in the horizon can vary, but we usually have assumed three to five years.

6 Presentation Techniques

Over the years presentation techniques for the results have varied. The intended message is always focused on the company’s current ability to pay claims, however, and that only a cash flow analysis of this type can measure this ability.

Furthermore, we always have focused first on this financial strength, using only those assets supporting our reserves. (We begin with assets equal to insurance liabilities - statutory basis, i.e., no surplus included.) In this way we uncover our balance sheet financial strength, showing our ability to meet adversity without drawing on existing company surplus. We believe that this makes the message even stronger.

Getting the message across requires the use of various measures that quantify this financial strength. We have used amounts of nominal net cash flow, cash flow net present value, and internal rate of return. These have been combined in various matrix formats to show the various combinations of interest rate, asset default, and reserve development risks that have been evaluated. The simplest formats are those that are most consistently well received.
6.1 Nominal Net Cash Flows

Presenting the nominal cash flows—asset inflows, liability outflows, net flow—is an effective way to communicate the financial strength available to meet company obligations. What this can show for balance sheet assets and liabilities is the amount by which expected asset cash flows exceed expected liability cash flows. This excess cash flow would be available to help manage the possibility of future adverse experience or, if this did not occur, would emerge as profit. Table 1 shows both the total amounts of the flows and the timing of the flows. Figures 1 and 2 are based on the data in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Inflow</th>
<th>Outflow</th>
<th>Netflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.70</td>
<td>4.00</td>
<td>-0.30</td>
</tr>
<tr>
<td>2</td>
<td>1.70</td>
<td>2.50</td>
<td>-0.80</td>
</tr>
<tr>
<td>3</td>
<td>1.50</td>
<td>1.40</td>
<td>0.10</td>
</tr>
<tr>
<td>4</td>
<td>1.60</td>
<td>0.90</td>
<td>0.70</td>
</tr>
<tr>
<td>5</td>
<td>1.60</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>6</td>
<td>1.10</td>
<td>0.70</td>
<td>0.40</td>
</tr>
<tr>
<td>7</td>
<td>1.00</td>
<td>0.70</td>
<td>0.30</td>
</tr>
<tr>
<td>8</td>
<td>0.70</td>
<td>0.60</td>
<td>0.10</td>
</tr>
<tr>
<td>9</td>
<td>0.60</td>
<td>0.40</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.40</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>11</td>
<td>0.30</td>
<td>0.20</td>
<td>0.10</td>
</tr>
<tr>
<td>12</td>
<td>0.10</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>13</td>
<td>0.08</td>
<td>0.07</td>
<td>0.01</td>
</tr>
<tr>
<td>14</td>
<td>0.15</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>15</td>
<td>0.10</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>16</td>
<td>0.10</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>17</td>
<td>0.09</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>18</td>
<td>0.06</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>19</td>
<td>0.06</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>20</td>
<td>0.06</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Totals</td>
<td>15.00</td>
<td>13.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>
6.2 Present Value

Cash flow present values are also an important measure in our analysis. Present values have been used in two ways.

- First, for our cash flow report we have included present values for many shock scenarios including the boundary scenarios (where the present value of the net cash flow equals zero). The report focuses on the range of answers and not the results of any one scenario.

- Second is the situation where we have needed to show financial strength in one or two slides or exhibits. Talking about many sce-
narios distracts from the balance sheet financial strength. Therefore, in this situation we have presented results for a single scenario, our base case scenario. The net cash flow present value is easy to quote. A disadvantage to present value, however, is that the number can draw attention from the main message of financial strength. Questions to us have included: Is this a market value? Is the discount rate before or after tax? What is the assumed borrowing versus reinvestment rate? etc., etc.

The fundamental difficulty is choosing a discount rate for the present value calculation that everyone feels is appropriate. A possible solution is to present the answer as "the present value at x% is equal to y" and be ready with several other answers at different discount rates.
6.3 Internal Rate of Return

Like the present value, the internal rate of return (IRR) is easy to quote. In addition, the IRR avoids the argument over what discount rate to use, and it communicates well to investment persons.

The IRR is not easily understood by non-investment persons, and it provides less information than nominal flows. One misinterpretation is that the IRR is the highest rate that the asset cash flows can withstand and still be sufficient to meet the liability cash flows. This is true only for constant interest rate scenarios. Finally, the IRR does have some limitations, e.g., sometimes the IRR is not a unique positive number.

In our cash flow report we use the IRR to provide the border interest rate (i.e., the interest rate where the present value of the net cash flows equals zero for a given combination of asset default and reserve development assumptions). We generally focus on the year to year changes in the IRR. If the IRR changes significantly, this usually is a signal to do more work to understand why the change occurred (sometimes uncovering problems with the data).

Generally we limit IRR use to our own analytical purposes and to situations where the intended audience is familiar with it.

References


Appendix

This appendix demonstrates an application of Altman's (1989) method to Schedule D – Part 1A data.

1. From Schedule D, Part 1A, schedule the amount of bond principal still outstanding by year, by rating. For example, class 1 bonds outstanding in year 5 include bonds maturing in years six through ten, ten through 20, and over 20 years. Government bonds are pulled as if they were a separate rating group, as we assume they have a 0 percent default rate.

2. The annual statement shows bonds by NAIC classes 1 through 6. Default rates come in rating groups AAA through B. This requires a translation of the above data by NAIC class into default table rating groups.

   Classes 2 through 4 translate directly into specific ratings (BBB, BB, and B). Class 1, containing AAA though A, was translated into a rating of AA. Classes 5 and 6 were grouped with those rated B. (This may distort the final answer for a company with significant class 5 and 6 bonds due to the high default rates for these bonds, although this is minimized due to NAIC rules restricting these investments.)

3. Translate the cumulative default probabilities from the default table into incremental default probabilities.

4. Apply these incremental default probabilities by rating and lag year against outstanding bonds by rating and default year to get default rates by year.

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29 Schedule D, Part 1A includes bonds by broad maturity ranges: 1 or less, 2-5, 6-10, 11-20, over 20. We translate these ranges into maturity years of 1, 3, 7, 15, and 25. Only the first 20 years were used, however, as default rates are not published beyond 20 lag years.

30 This has minimal impact, as default rates in the tables vary little between A, AA, and AAA ratings.

31 An additional problem exists in that bonds below class 2 (rating BBB, which is the lowest rating for investment grade bonds) are carried at market in the property/casualty annual statement. Therefore Schedule D, Part 1A would tend to underestimate the level of lower rated bonds in the predefault bond cash flows. This bias would be hidden where coupon rates are above current yields and exacerbated when coupon rates are below current yields.
Numerical Example of Default Rate Calculation

Steps 1 & 2—Schedule amount of bond principal outstanding, by year, by rating. See Tables 1 and 2.

Table 1
Excerpt From Schedule D, Part 1A*
Quality and Maturity Distribution of Bonds

<table>
<thead>
<tr>
<th>Class</th>
<th>Range of Maturities in Years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 1 Year</td>
<td>1-5</td>
</tr>
<tr>
<td>1</td>
<td>27,034</td>
<td>56,306</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Using 1994 Best's Aggregates & Averages

Table 2
Assumed Outstanding Principal of Bonds by Rating Group

<table>
<thead>
<tr>
<th>Year</th>
<th>Rating</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gov't</td>
<td>138,954</td>
</tr>
<tr>
<td>2</td>
<td>AAA</td>
<td>274,291</td>
</tr>
<tr>
<td>3</td>
<td>AA</td>
<td>247,258</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>190,952</td>
</tr>
<tr>
<td>5</td>
<td>BBB</td>
<td>18,090</td>
</tr>
<tr>
<td>6</td>
<td>BB</td>
<td>2,460</td>
</tr>
<tr>
<td>7</td>
<td>B or Lower</td>
<td>1,974</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>4-6</td>
</tr>
</tbody>
</table>

| Total | 446,905 | 400,296 | 400,296 | 279,894 |

Notes: Class 1 bonds are assumed to be AA. Year 1 outstanding (O/S) is total principal for the class; Beginning year 2 O/S = year 1 O/S, minus year 1 maturities; Beginning year 4 O/S = year 3 O/S, minus 1-5 year maturities (assuming principal matures at the midpoints of the intervals, e.g., 3.5 years for the 1-5 year maturities); etc.

Step 3—Translate cumulative default probabilities to incremental default probabilities, e.g., cumulative AA default rate at three and four years equals 0.001 and 0.002 respectively; therefore, incremental de-

32A table of cumulative default rates is published annually by Moody's Investors Service. To get the incremental rates from the cumulative default table, one must take
fault rate for year 4 is \((0.002 - 0.001)/(1 - 0.001) = 0.001\). These incremental default probabilities are shown in Table 3.

### Table 3

**Incremental Default Assumptions (Moody's, 1994)**

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>AA</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>A</td>
<td>0.0%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.2%</td>
</tr>
<tr>
<td>BBB</td>
<td>0.2%</td>
<td>0.3%</td>
<td>0.4%</td>
<td>0.6%</td>
</tr>
<tr>
<td>BB</td>
<td>1.8%</td>
<td>2.6%</td>
<td>2.6%</td>
<td>2.7%</td>
</tr>
<tr>
<td>B or Lower</td>
<td>8.3%</td>
<td>7.1%</td>
<td>6.6%</td>
<td>5.5%</td>
</tr>
</tbody>
</table>

Step 4—Weight incremental default rates by rating and lag year against outstanding bond principal by rating and lag year to get average default rates by year:

### Table 4

**Average Default Rates**

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Rating Groups</td>
<td>0.08%</td>
<td>0.09%</td>
<td>0.15%</td>
<td>0.17%</td>
</tr>
</tbody>
</table>

the conditional probability of default in year \(n\), given that default does not occur before year \(n\). If \(C(n)\) is the cumulative default rate through year \(n\), then the incremental default rate is \([C(n) - C(n - 1)]/[1 - C(n - 1)]\).